C. arabica from one to three inches long; this peculiarity is attempted to be explained by Lamarck and others, who assert that when the animal has formed a complete shell, as it has not the faculty of enlarging its size, it is obliged to quit its shell and form a new one, in the same manner as the *Annulosa* cast their skins, and by that means the same animal forms many shells; but I believe there is not the slightest ground for this notion, for these several reasons: 1. If it happens in this genus, it certainly should do so in several of the other genera, as the *Strombi* and *Pterocerata*, where the mouth is fully formed in the small shell, and there is no appearance of varices in the large specimens. 2. The muscular attachment of the shell to the animal is one of the best conchological characters that distinguish this class of animals from the shelly and sandy cases of the *Annulosa*; as the *Dentalia* and *Sabellæ*, where the animals can withdraw themselves at pleasure; but in the Mollusca I do not think it possible to be done, but by such force as would destroy the individual. 3. There is no analogy between the *crust* of the *Crustacea* and *Annulosa*, and the *shells* of *Mollusca*; so that it is false reasoning to judge of the possibility of one from the other."—*Zoological Journal*, vol. i. p. 73.

XLII.—*Researches on the Primary Modifications of Organic Matter, and on the Formation of Cells.* By M. Coste*. (Part the 1st.)

Every one is acquainted with the celebrated experiment of Duhamel, who, after having bent the summit of a tree towards the earth, inserted the extremities of its branches into the soil, and afterwards turned the trunk so that the roots projected externally, found that these same roots, which had become aërial, shot out branches, whilst the branches which had become terrestrial sent off roots.

This experiment, the result of which a host of experiments known to agriculturists would have enabled us to foretell, since it was an established fact, that a root which was exposed by any inequality of soil produced a shoot, and that a stem which had been sliced off produced a root, provided that the wound was sheltered from exposure to the air and surrounded with moist earth; this experiment, I say, furnished so decisive a proof of the identity of the roots and stems, that the objections which were at first made to it have neither prevented our taking advantage of the fertile idea which it reveals, nor arrested the progress of the revolution which the development of its consequences introduced into the science of organization.

* Translated from the Comptes Rendus for October 20, 1845.

Thus, as soon as the demonstration of this identity was apparently obtained, and, under the influence of this conviction, naturalists sought for the explanation of so remarkable a phænomenon, science seemed to acquire fresh vigour, and all those facts which now form the basè of phytogeny appeared to emanate from the attempts which were made to solve this interesting problem.

In fact, how could it happen that the same part of a vegetable, under the influence of external circumstances, produced organs which then appeared so different as a stem, a root, a bud, or a leaf? To what structural cause could the possibility of so remarkable a metamorphosis be attributed? Such was the idea which observers entertained, and which directed their researches in the new path opened to them.

Success speedily crowned their endeavours, and their earliest labours in unveiling the true structure of plants led them to the important result, that a vegetable, be the complication of its organs ever so great, is essentially nothing more than a collective being, composed of an assemblage of vesicles, utricles or cells, which are so many living individuals, originally identical, enjoying the power of growth, multiplication and capability when occasion requires of reproducing the plant of which they form the constituent materials. If these vesicles, utricles or cells are not excited to any further development, they continue simply to form part of the tissue of the plant they constitute; or they may be absorbed to serve for the nutrition of those cells, which, being more advantageously placed, are destined for new transformations: but if, on the contrary, the influence of more favourable circumstances is felt, we then find that their original aptitude is aroused, and is called into action under the most varied forms; *without however ever exceeding the assigned limits of the species to which they belong.*

The original identity of vegetable cells, and the power attributed to them of being transformed in so varied a manner, is not an hypothesis created by the necessity of any theory; it is a fact confirmed by experiment, and which can be reproduced at pleasure; but this is not the place for studying the mechanism by which such metamorphoses as these are to be accomplished. It is sufficient to know at present that vegetable tissue is exclusively composed of cells, to understand how physiologists, guided by analogy, when direct observation had put them in possession of this fact, were necessarily led to inquire whether the animal organization was not similarly placed as regards structure.

This problem was much more difficult of solution, for the organs in animals are capable of attaining so great a degree of complication, that it frequently becomes impossible to penetrate into their structure as observed in the adult; but if precaution

be taken to study the tissues in the germ itself, and at the time of their earliest origin, we can then clearly recognise that their structure is for the most part composed, like those of vegetables, of cells, which are so much the more easily recognised the less their forms are obscured by development.

Now, from the moment at which it was demonstrated that the cell constitutes the base of all the organic tissues, that it is as it were the integral molecule, we could not fail to attach the utmost value to the discovery of the mechanism of its formation. This was, in fact, one of the most curious and most secret phænomena in nature which direct observation could unfold; for by this new conquest science extended the limits of its dominion so far as to observe living matter, still diffuse, commencing to individualize itself in one of the most simple forms which organization is capable of assuming, that is, in that of a vesicle, utricle or cell.

The honour of the commencement is due to M. Mirbel. This physiologist first investigated the origin of the cell from the cambium, and the formation of its walls at the expense of this mucilage. In fact, in the large interstices which the vegetable utricles leave between them, or even in the cavity of these utricles, there exists a mucilaginous matter comparable to gum-arabic, in which the most perfect instruments cannot recognise any trace of visible organization, but which becomes the generating element of every organic form. This diffused matter, which Grew discovered more than 150 years ago, and the use of which he surmised, has been traced by M. Mirbel through the principal modifications which it undergoes in certain vegetables, and the following exhibits the succession of phænomena through which he has seen it pass in producing the cells of which vegetables are composed.

In a series of sections of the extremity of a root of the date-tree, consequently at the point of that root where the cambium is in progress of increasing elaboration, he saw in the mucilaginous substance a multitude of irregularly-spheroidal homogeneous masses, evidently resulting from a concentration of the mucilage, which in each condensed mass already exhibited the earliest rudiments of future organization. In the centre of each mass a cavity is soon formed, which gradually enlarges, and accumulates around it the matter by which it is bounded; and this matter, thus moulded, being expanded into a membrane by the dilatation of the central cavity, finally represents a hollow sphere, which is nothing more than a vesicle moulded by the cavity which it circumscribes. In this manner, by a kind of eccentric condensation of the mucilaginous cambium, the walls of the vegetable cells are formed, and the amorphous matter passes, under the observer's eye, from the state of diffusion into active life, and thus becomes suscep-

tible of playing a more or less active part in the organization of plants. But this mode of formation of the walls of the cells not being the only one observed by M. Mirbel, this physiologist has been induced to admit, that in vegetables nature attains her object by different means.

However, this manner of viewing and judging of the phænomena of which the cambium is the seat was soon accompanied by a diametrically opposite system, the exclusive foundation of which does not admit of the possibility of an exception. This system, contrived by Schleiden to explain the formation of the vegetable tissue, and applied by Schwann to the organization of animals, as we shall presently see, is essentially no more than a generalization *à priori* of Purkinje's theory of the development of the egg in the ovary,—a theory, a large part of which has unfortunately lost much of its value from new discoveries which have diminished its importance, or even reduced it to the level of the most rare exceptions.

Purkinje, after having recognised that the germinal vesicle, among all the component parts of the bird's egg, was that which from its origin had a proportionately more considerable development, supposed that it was first formed, and considered it as a centre around which were successively deposited, first the *vitellus*, and then the vitelline membrane, which, in its turn, coagulated at the periphery of the yolk to complete the ovarian egg, and to inclose its elements in an enveloping membrane. This successive union of concentric parts, mechanically superadded around each other, so that the most external are the most recent, having appeared to Schleiden and Schwann the most simple means of conceiving the formation of the vesicular walls, these naturalists formed it into a general theory of the development of the cell; and with them the enunciation of the special fact, modified as we shall presently show, has become the foundation of a universal principle.

Consequently they admitted, that in the diffuse and structureless homogeneous substance, the *cytoblastema*, by means of a concentration of this substance, corpuscles were formed; these were so extremely minute, that even the highest powers of the microscope did not allow of their always being detected. These corpuscles, called *nucleoli*, are so many centres around each of which a layer of finely-granular matter is deposited, which is not at first distinctly limited in its circumference, but which finally becomes more clearly outlined, and forms more or less regularly spheroidal, elliptical or lenticular agglomerations.

Each of these minute accumulations of amorphous matter around one or even several *nucleoli*, which they unite, is called a *cytoblast* or *nucleus*, and forms the second phase of the process

of organization, which, according to this theory, prepares the way for the cell-wall, of which all the anterior phænomena are indispensable precursors.

Lastly, when the cytoblast or nucleus is formed around the nucleolus, and the total mass represented by their assemblage has assumed a certain volume, we find deposited on its exterior a new layer of substance, the fragile margins of which, at first vaguely defined, are soon consolidated and strengthened by the addition of new molecules. This more or less thin and delicate mass, which is sometimes homogeneous and gelatinous, sometimes granular, is nothing more than the cellular wall which is developed on the surface of the cytoblast, as it were around a temporary frame-work, the presence of which becomes useless as soon as the structure which it supports is completed.

But, when deposited around the cytoblast or nucleus, the new cell does not inclose this cytoblast in the centre of the cavity which it is about to circumscribe, as we should suppose; on the contrary, it fixes it between the molecules which are about to form its generating wall, retains it inclosed amongst these molecules, and forms of it an integral part of the parietal membrane. This incorporation renders the cell-wall much thicker at that part which the cytoblast occupies than in any other part of its extent; and it is for the purpose of expressing the appearances produced by this inequality of thickness, that the statement has arisen that the new cell resembled a watch-glass placed upon its dial. In this comparison, the watch-glass represents the thin and diaphanous portion of the wall; the dial corresponds to that part which the presence of the nucleus renders thicker; and the space comprised between these two parts, which must be considered as continuous, is intended to give an idea of the cellular cavity which is forming.

When the new cell has acquired sufficient solidity, the persistence of an internal frame-work not being any longer necessary to support the strengthened walls, the cytoblast or the nucleus, attached to one point of the thickness of the parietal membrane, has no longer any part to play, and hence it should be atrophied and disappear. Then, in proportion as the cell enlarges, a peculiar liquid is introduced into its cavity and entirely fills it. This liquid, in which more or less abundant granulations may arise, forms the cell-contents, properly so called. But the cellular contents have nothing in common with the cytoblast or nucleus, and would in no case be required to fulfil the generating function which theory attributes to this same nucleus, since, according to this theory, the appearance of the cellular contents is always subsequent to the production of the parietal membrane. Now we shall show, in opposition to this view, that the

cellular contents, in a great number of cases, have a direct influence, and that the vesicle which incloses them is generally developed around them.

Finally, when the phases of a first generation are accomplished, new cells are formed in the cellular contents by the same mechanism by which the maternal cells are developed from the primitive cytoblast. In this manner, by an incessantly-renewed repetition of the same phænomenon, the organic tissues, according to this theory, prepare the materials of their growth and multiplication.

Such is the theory, deprived of the vagueness and the obscurities which manifestly arise from the uncertainties which a deficiency of precise observations leaves in the minds of its authors; such is the theory which it is proposed to elevate to the rank of a universal principle. Let us see how far an attentive examination of the facts will authorize the pretensions of such a doctrine. The fundamental character of this doctrine consists, as we have seen, in the succession of four distinct periods, of which the evolution of each cell should always consist.

The first is represented by the appearance of the nucleolus, which is the basis of the structure, and itself results from a simple agglomeration of the molecules of the cytoblastema.

The second corresponds to the deposit and to the coagulation of the cytoblast or nucleus around the nucleolus, considered as the unique and exclusive centre of all cell-formation.

The third, to the deposition and coagulation of the cell-wall around the cytoblast, which it grasps at one point of its substance, and on one side of which it appears at first applied like a watch-glass upon its frame.

The fourth is expressed by the absorption of the nucleus and by the admission of cellular contents, which, being subsequently introduced, cannot consequently have taken any part in the formation of the parietal membrane.

Now if this is the sole mechanism by means of which all organic cells are developed,—if it be true that the four fundamental modifications which prepare the way for their walls are always produced in the order of succession which we have pointed out, it should result that wherever there are cells in the course of formation,—the cytoblastema should present in the metamorphoses of its substance, each of the material modifications which constitute the terms of this essential succession. If then the theory is to aspire to the rank of a general doctrine, it will be necessary that in the self-organizing mucus we should always be able to meet with the free nucleolus, the nucleolus inclosed by the cytoblast, the cytoblast at the moment at which the cell-wall is deposited on its periphery; and finally the cyto-

blast, inclosed in the thickness of the parietal membrane, disappearing in proportion as the cell-contents are introduced into the cavity of the latter.

But when we search for the facts upon which so radically exclusive a theory is founded, we experience the twofold astonishment of not meeting, in those authors who originated it, with a single example the value of which we cannot seriously contest, and of not finding in nature those abundant proofs which cause a system to prevail, or at least allow the formula to remain, as the most faithful expression of the most numerous category. Thus, in examining the proofs cited by Schwann in support of this hypothesis, we find that they may be reduced, as M. Vogt has remarked*, to a single observation directly made on cartilage; and yet this observation, presented by Schwann himself as very doubtful, has been shown to be false by the researches of M. Vogt on the cartilage of the accoucheur-toad. In fact, in a very large number of cases, the nucleolus, to which the theory attributes the exclusive privilege of causing the amorphous matter to produce the cell-walls; in a very large number of cases, I say, the nucleolus never appears free and isolated in the midst of the cytoblastema. On the contrary, we always find that this corpuscle, even from the first commencement of its appearance, is still inclosed in the cavity of the cell, which is previously formed, frequent instances of which we find in the tissues of the embryo of osseous fishes; it is evident that in these cases at least the nucleolus has taken no part in the formation of the cell, as it was not in existence when the latter was produced. In other cases, this corpuscle did not appear at any period of the existence of the cells, and consequently we should have no motive for making it intervene as a determining cause, since it does not leave to the theory even the pretext of co-existence. This may be easily verified by studying the development of the large cells which form the internal expansion of the umbilical vesicle of serpents.

Hence the tardy appearance of the nucleolus in certain cases,

* "In examining the proofs cited by Schwann in support of his opinion, we find," says M. Vogt, "that they resolve themselves into a single observation made upon cartilage; and moreover it must be remarked that M. Schwann himself presents it to us as very doubtful. In fact, I believe that I have shown in my researches on the accoucheur-toad, that this opinion is probably erroneous, and that an old cellular cavity almost closed, or the half-absorbed nucleus of an old cell, had been taken for the nucleolus of a cell in process of formation. I have then no doubt, from the observations which we now possess, that the nucleolus, far from being the primitive rudiment of the cell, is, on the contrary, nothing more than a formation resulting from one of the last metamorphoses which the cells undergo. . . . . These various facts could not fail to excite doubts in my mind regarding Schwann's theory, and I concluded by considering that it was based upon few facts only, and these were mostly susceptible of another interpretation."

and its total absence in others, form a serious impediment to the theory which locates the exclusive determining cause of all cell-formation in the pre-existence of this corpuscle. This also shakes the very foundations of the doctrine, and tends at the least to restrain its application.

As regards the cytoblast or nucleus, M. Vogt has already shown that it has no influence on the formation of the cell-walls of the embryo of the osseous fishes: I have been enabled to convince myself that the large diaphanous vesicles in the spinal cord of the Batrachia do not appear until after the production of the parietal membrane of these vesicles.

But because the intervention of the nucleolus is not always necessary for the formation of the cells, and because the cytoblast or the nucleus does not itself, in a certain number of cases, retain the function assigned to it by theory, must we necessarily conclude that the cells are never developed around a centre upon which the forming walls would mould themselves? Undoubtedly we shall have frequent opportunities of observing limited masses of matter becoming coated with an envelope, and thus constituting the contents of the pouch which is formed at their periphery; but we shall then remark, that in most of these cases this happens in a very different manner from what the theory supposes; for the matter which has constituted the centre, instead of being absorbed by the parietal membrane, to make room for the cellular contents subsequently introduced, itself forms the cellular contents, fills the cavity of the new cell, may there be applied to different prolonged functions, may live longer than the cell itself, or remain in reserve in the cavity of the latter, to serve the further purposes of nutrition or generation of new cells. The egg, in the two united vesicles of which it is composed, presents us with striking examples of a survival of the matter which has served as a generating centre, because we there see the germinative corpuscles persist when the parietal membrane which incloses them is dissolved, and take part in the new formations after it has been completely absorbed. The yolk there survives the vitelline membrane, and whilst the latter is gradually destroyed from the earliest period of its development, we see the yolk continue to nourish the embryo until after its birth.

Such are the grave, numerous and decisive objections which arise against a doctrine, which must rather be considered as a bold invention of the mind than the carefully-considered expression of satisfactory observation; but although the bases of this doctrine are uncertain, it has not the less rendered an eminent service to science, because in the commencement it gave rise *à priori* to the conception of the possibility that cells might be developed around a centre; and its influence has been very

great in directing observers in a fruitful path and in exciting important researches, among which we may mention those of Valentin, Vogt, Bergmann, Reichert, Bischoff, Barry, Lebert and Henle. In my turn I shall make known the result of the observations which I have made upon so disputed a subject—observations which during several years have been many times detailed in the course of instruction which I give in the College of France.

XLIII.—*Anatomical and Physiological Observations on some Zoophytes.* By John Reid, M.D., F.R.C.P.E., and Chandos Professor of Anatomy and Medicine in the University of St. Andrews.

[With a Plate.]

In the following observations upon the structures and actions of some of the Zoophytes obtained from the shore of the bay of St. Andrews, I have confined myself to those points which are either new, or which appeared deserving of additional illustration. In using the terms *superior* and *inferior, upper* and *lower* in reference to the *relative* position of different parts of the polypidom, in the descriptive parts of this paper, the polypidom is supposed to be in the erect position, so that these terms correspond to *anterior* and *posterior* when the polypidom is placed horizontally. In using the term *anterior surface,* I mean the surface on which the apertures of the polype-cells are placed, so that this corresponds to the upper surface when the polypidom is laid horizontally for examination.

Cellularia reptans. This polype grows in considerable abundance close upon low-water mark, on the exposed surface of a stratum of clay-slate and conglomerate, interposed among strata of sandstone belonging to the carboniferous series. Growing along with it, but in much smaller quantities, are *Cellularia scruposa, Crisia chelata, C. eburnea, Pedicellina echinata, Vesicularia spinosa, Valkeria imbricata* and *Plumularia falcata,* none of which have I hitherto found adhering to the surrounding strata of sandstone.

The polypidom of this polype possesses some structures which as far as I am aware have not yet been described. At the external and upper angle of the cell, and posterior to the two spines attached to this angle (Pl. XII. fig. 1 *a*, fig. 2 *c, a, b*), three of these structures are found*. The uppermost of these is a hollow process (fig. 2 *b*), the superior extremity of which is free, looks outwards and a little forwards, and has an aperture notched on the

* Part of this process is seen on looking at the anterior surface of the polypidom, as is represented in Plate XII. fig. 3 *b*.